LAC-20

2 Axis Controller/Amplifier

User Manual

Version C

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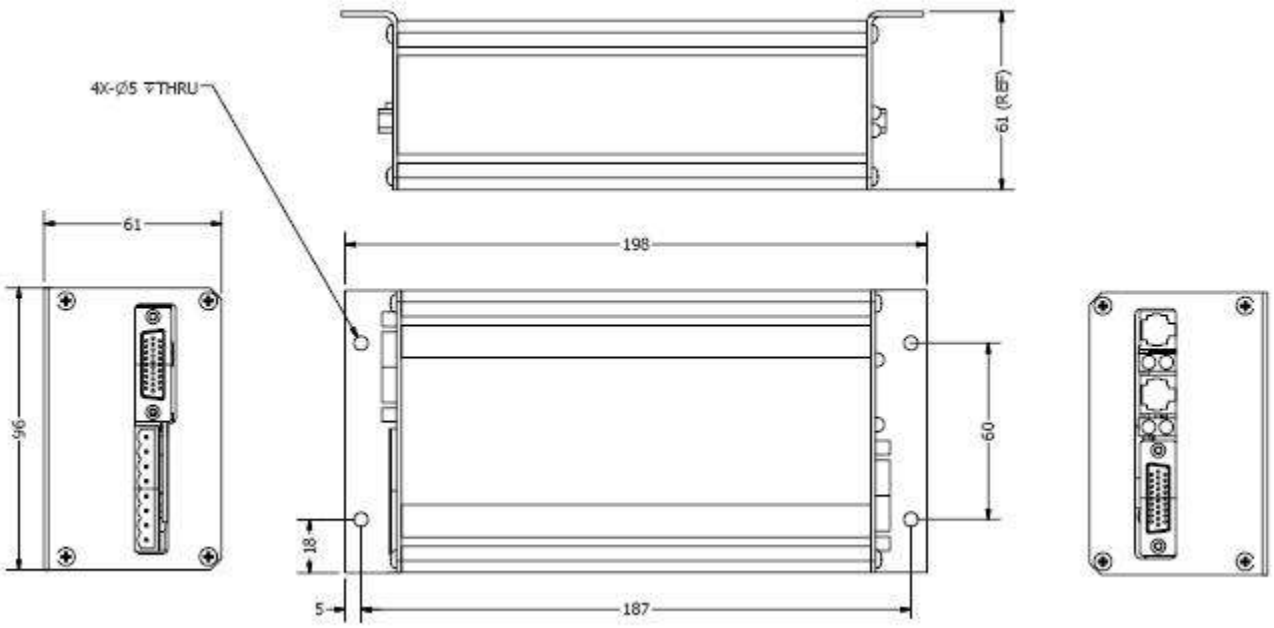
Contents

LAC-20 Specification and Features:

Number of Motion Axis	2
Control Algorithm	PID
Speed of DSP Controller	40 MHz, 40 MIPS
Motor Control	DC Brush, DC Brushless
Operation Mode	Stand along, Slave – in multi-axis
Control Mode	Position, Velocity, Torque, Open Loop
Nominal PWM Frequency	20 KHz
Main Power Supply	12 – 48 VDC
Peak Current	6 A Per Axis
Continuous Current	3 A Per Axis
Logic Supply:	5 VDC, 600 mA
Encoder Supply	5 VDC
Encoder and Index Input	Single Ended or Differential
Encoder Count Rate	6.7 MHz Max.
Position Range	32 bits
Velocity Range	16 bits integer part, 16 bits fractional part
Acceleration Range	16 bits integer part, 16 bit fractional part
Feedback Signal	Incremental encoder, Index, Hall, Current, speed estimated from position, DC bus voltage
General Digital Input	8, TTL
General Digital Output	8, TTL
Dedicated Digital Input	12, TTL
Dedicated Digital Output	4, TTL
Analog Input	4, with 10 bit resolution and ±10V
Programming platform	EasyMotion Studio
Internal Memory	1.5K x 16 SRAM Per Axis
External Memory	8K x 16 serial E²ROM Per Axis
Communication Interface	1 Port Per Axis RS232 up to 115200 bps CAN bus 2.0B up to 1Mbit/s
Integrated Protections	Over Voltage, Over Current, Under Voltage, Over Temperature, I²t
Operation Ambient Temperature	0 – 40 °C
Dimension	198 mm x 96 mm x 60 mm

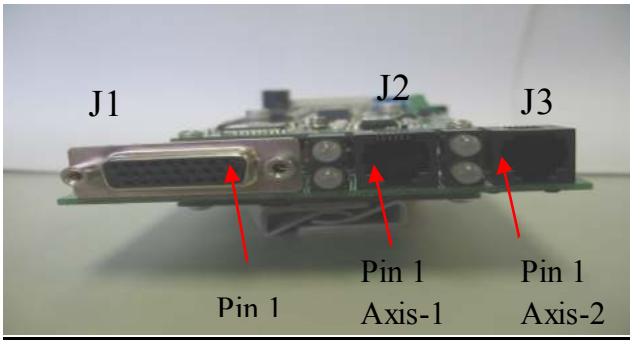
Outline Drawing:

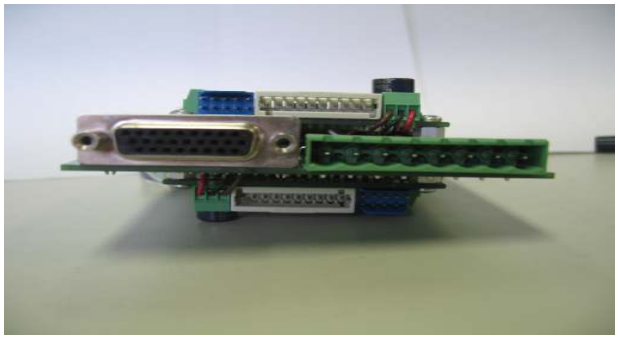


SMAC LAC-20, the new 2-axis motion controller-drive is engineered with two single Technosoft ISM4803 high-performance intelligent servo modules, which are combining motion controller and drive functionalities into a single compact unit. The LAC20 ISM module is a flexible, cost effective and compact solution, particularly adapted for distributed and coordinated control of brushless, DC, linear or step motors of powers up to 150W, with voltages up to 48V. Typical applications include distributed motor control with possibilities of gearing and electronic CAM functions in a CAN network operation. Targeted for medium to high volume applications, the ISM hardware structure is based on a cost optimized design integrating all the basic motor control functions on one double-sided card format. A series of I/O signals, both digital and analogue, are available for easy interfacing with the application. A complete set of high-level Technosoft Motion Language (TML) instructions permit to define and start complex motion sequences from your host, PC, or to execute pre-stored motion sequences selected from I/O lines, in a stand-alone mode.

The embedded Intelligence of the ISM facilitates the configuration and programming of the module through a high level graphical interface as the EasyMotion Studio.

LAC-20 Pin Layout





J1 – User I/O Interface Connector
High Density DB-26, Female

1. Aixs-1, OUT_0
2. Axis-2, FDBK
3. Axis-1, IN_1
4. Axis-2, OUT_3
5. Axis-1, OUT_3
6. Axis-2, IN_1
7. Axis-1, FDBK
8. Axis-2, OUT_0
9. NC
10. Axis1&2, ENABLE
11. Axis-1, IN_0
12. Axis-2, REF
13. Axis-1, OUT_2
14. Axis-2, IN_2
15. Axis-1, IN-3
16. Axis-2, OUT_1
17. NC
18. NC
19. +5 VDC
20. GND
21. Axis-1, OUT_1
22. Axis-2, IN_3
23. Axis-1, IN_2
24. Axis-2, OUT_2
25. Axis-1, REF
26. Axis-2, IN_0

J2, J3 – RS232 & CAN Communication Interface
6 pin Phone Module

1. CAN-L
2. CAN-H
3. Rx, Receive Data
4. Tx, Transmit Date
5. GND
6. NC

J5 – Servo Encoder Interface Connector
High Density DB-26, Female

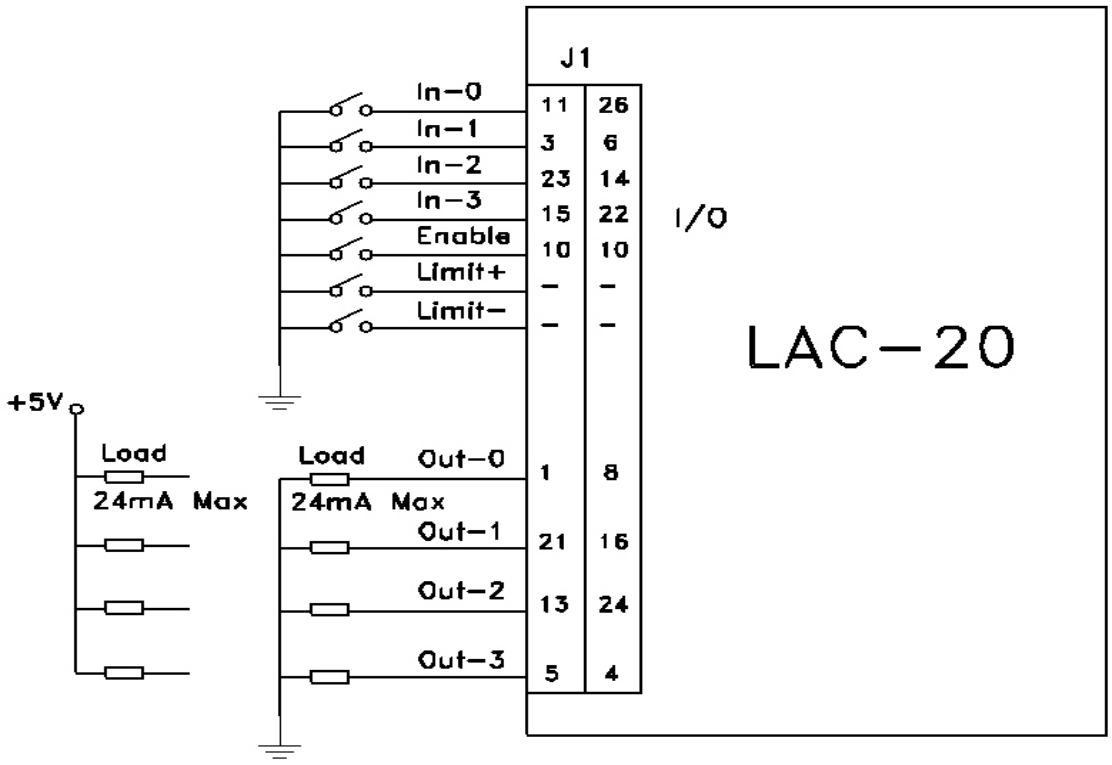
1. NC
2. NC
3. NC
4. +5 VDC
5. +5 VDC
6. Axis-2, Encoder B-
7. Axis-2, Encoder B+
8. Axis-1, Encoder B-
9. Axis-1, Encoder B+
10. NC
11. NC
12. NC
13. GND
14. GND
15. Axis-2, Encoder A-
16. Axis-2, Encoder A+
17. Axis-1, Encoder A-
18. Axis-1, Encoder A+
19. NC
20. NC
21. GND
22. GND.
23. Axis-2, Encoder Index-
24. Axis-2, Encoder Index+
25. Axis-1, Encoder Index-
26. Axis-1, Encoder Index+

J6 – Power Interface
5 Pin 5.08mm Center Phoenix

1. Axis-2, W
2. Axis-2, Motor- / V
3. Axis-2, Motor+ / U
4. Axis-1, W
5. Axis-1, Motor- / V
6. Axis-1, Motor+ / U
7. Main Power, +24V
8. Main Power, Return

Digital I/O Interface

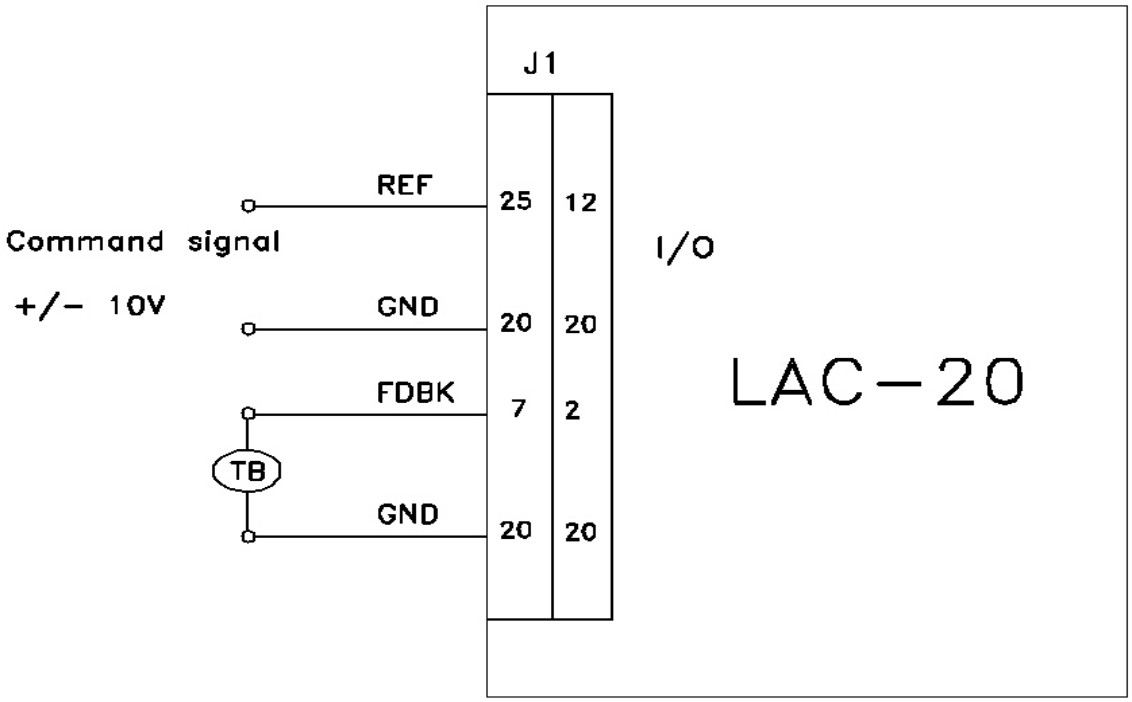
The LAC-20 provides total 8 general purpose inputs and 8 general purpose output, each axis has 4 inputs and 4 outputs. In addition, each axis has 3 dedicated inputs, Enable, Limit+ and Limit-, and 2 dedicated outputs, Ready, and Error. All inputs and outputs are compatible with TTL signal level and maximum current on outputs is 24 mA each.



Digital I/O Connection

Analog Inputs

The LAC-20 provides total 4 analog inputs with 10 bits resolution on A/D conversion; each axis has 2 analog inputs, REF and FDBK. The analog input range is +/- 10V that reference to GND. The input REF can be used as analog position, speed reference, and torque reference. The input FDBK can be used as tacho meter feedback.

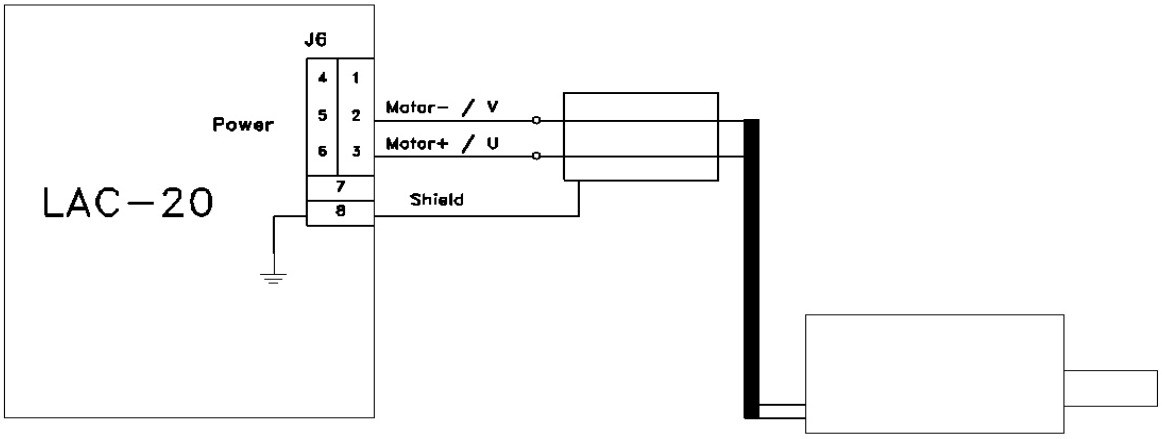


Analog Input Connection

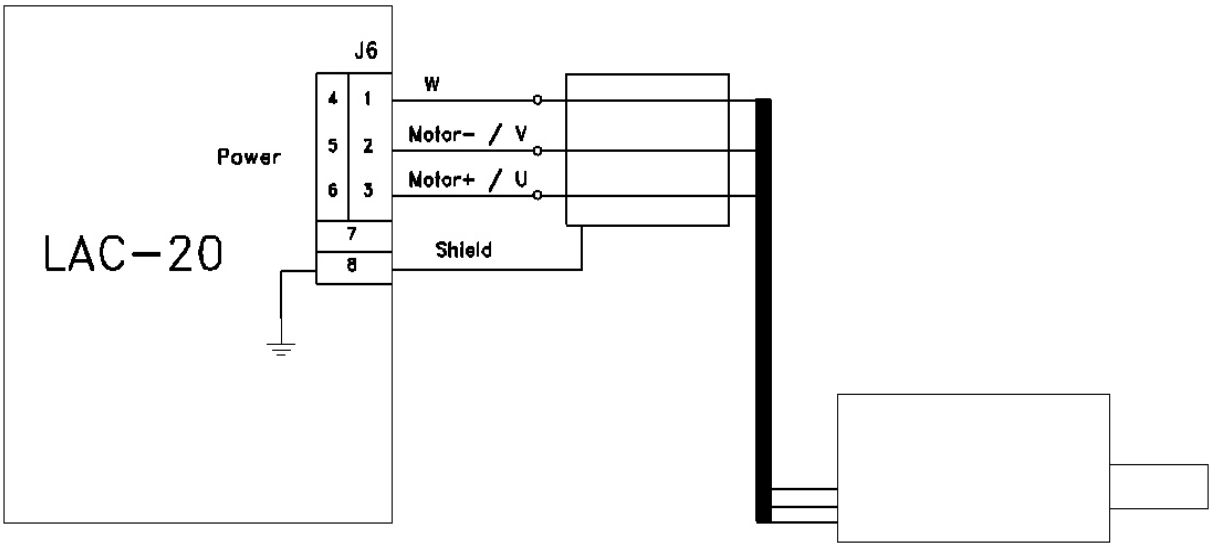
DC Brush and Brushless Motor connection

CAUTION:

Before connecting the motor, be sure you have the right application programmed to E²ROM otherwise you can damage the motor and drive.
At Power-on the TML application is automatically executed. See special instruction on how to disable this auto run feature.



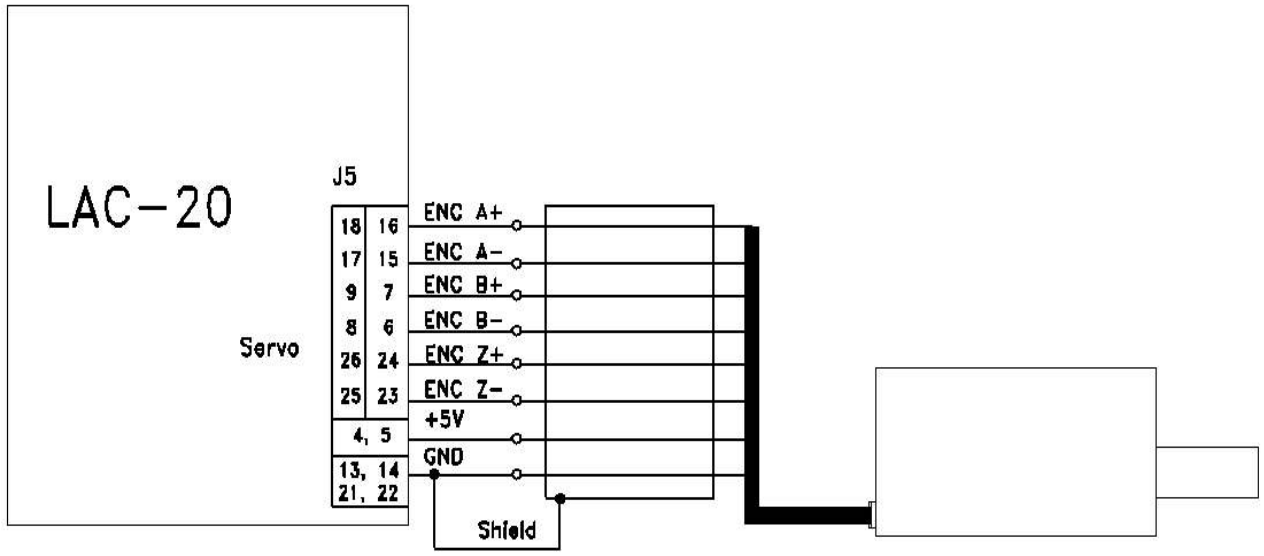
Brush Motor Connection



Brushless Motor Connection

Differential Encoder Connection

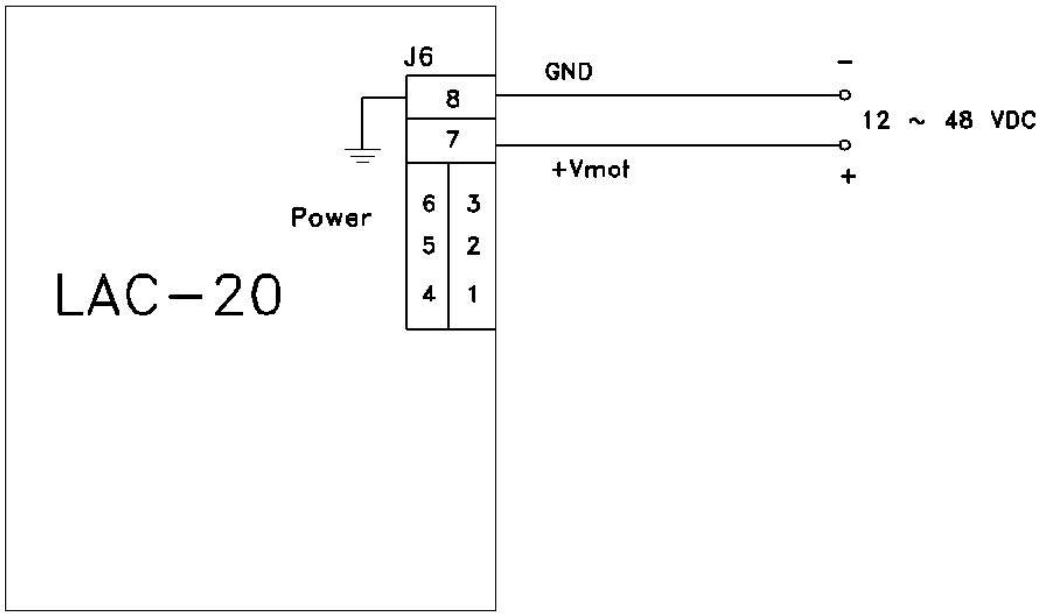
The LAC-20 provides 2 channels (A and B) of quadrature encoder interface with index signal input. +5VDC requires minimum of 50mA.



Differential Encoder Connection

Power Supply Connection

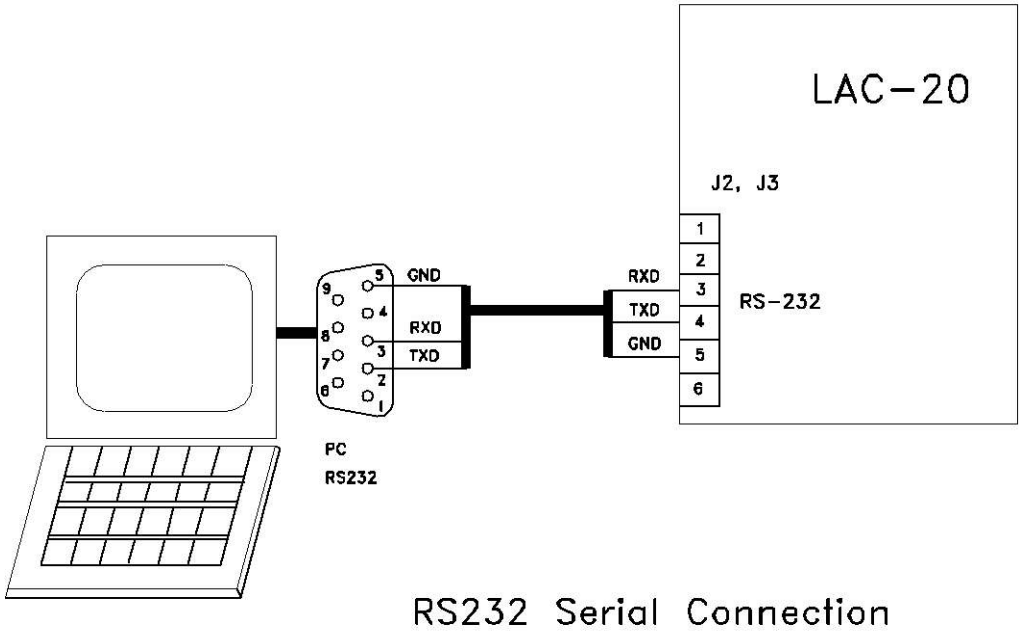
The LAC-20 has wide range of Motor Power (Vmot) input between 12 to 48 V DC. The maximum supply Voltage is 50VDC.



Power Supply Connection

Serial RS232 Interface connection

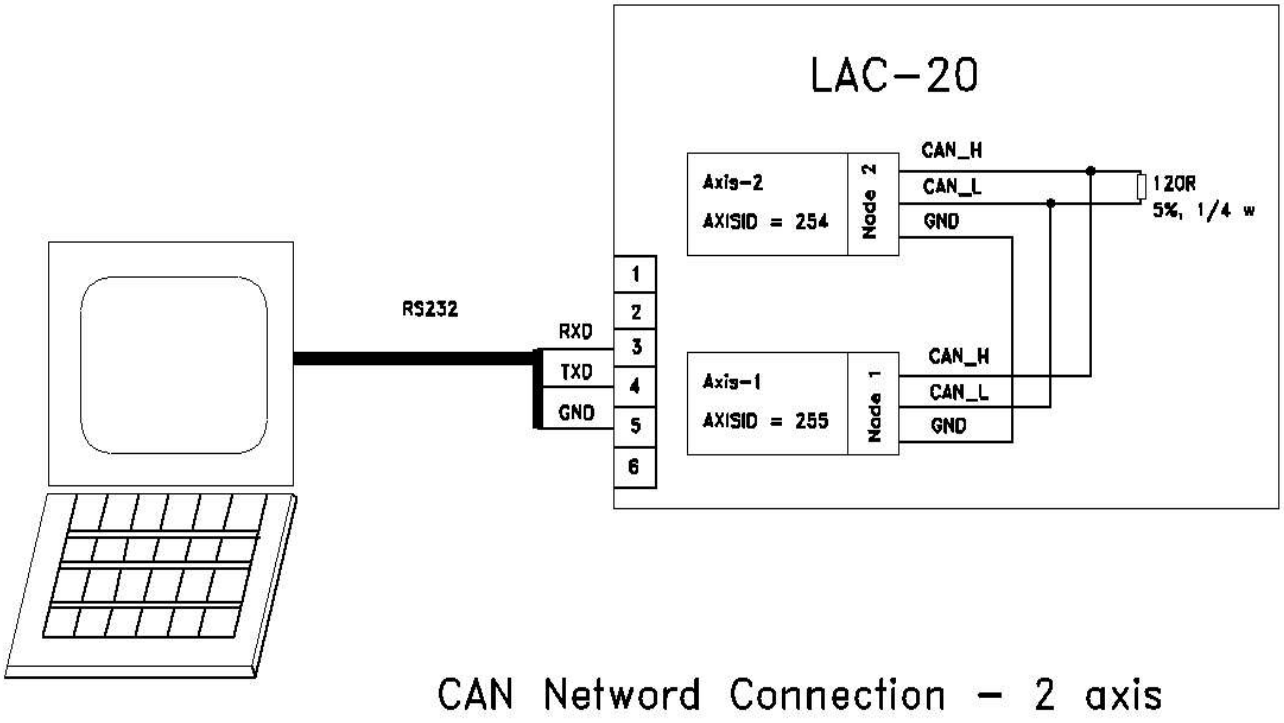
The LAC-20 provides 2 ports of serial RS232 communication interface, each axis has one independent RS232 port. LAC-20 communicates with a host computer via RS232 port. The RS232 port of LAC-20 has compliance with standard of TIA/EIA-232-C. The baud rate can be set between 9600 to 115,200 bits per second.



RS232 Serial Connection

CAN Connection

The LAC-20 provides 2 ports of CAN communication interface, each axis has one CAN port. Inside LAC-20, these two CAN ports are tired into chain. A terminator resistor of 120 ohm is installed into the network at axis-2 node. LAC-20 CAN ports have compliance with standards CAN-Bus 2.0B; ISO11898-2. The speed of CAN bus can be up to 1M bits per second. In the multiple-axis CAN network, the aixsID must be set to each axis node. The first axis (axis-1) node should set the axisID as 255. The second axis (axis-2) can be assigned axisID between 1 – 254. The axisID can be set by software and/or by hardware (by jumpers)



CAN Netword Connection – 2 axis

Available Memory Area

The LAC-20, the two axis controller drivers, each driver has two types of memory: a 1.5Kx16 SRAM (internal) memory and an 8Kx16 serial E²ROM (external) memory.

The SRAM memory is mapped both in the program space (from 8200H to 87FFH) and in the data space (from A00H to FFFH). The data memory can be used for real-time data acquisition and to temporarily saved variables during a TML program execution. The program space can be used to download and execute TML programs. It is the user's choice to decide how to split the 1.5-K SRAM into data and program memory.

The E²ROM can be imaged as 8Kx16 program memory mapped in the address range 4000H to 5FBEH. It offers the possibility to keep TML programs in a Non-volatile memory. Read and write accesses to the E²ROM locations, as well as TML programs downloading and execution, are done from the user's point of view similarly to those in the SRAM program memory. The E²ROM SPI serial access is completely transparent to the user.

Programming

Easy Motion Studio

Easy Motion Studio provides high level graphical development environment. It supports the configuration, parameterization and programming of the drive through

- Motion system set-up wizard
- Tuning assistance
- Definition, programming and testing of motion sequences.

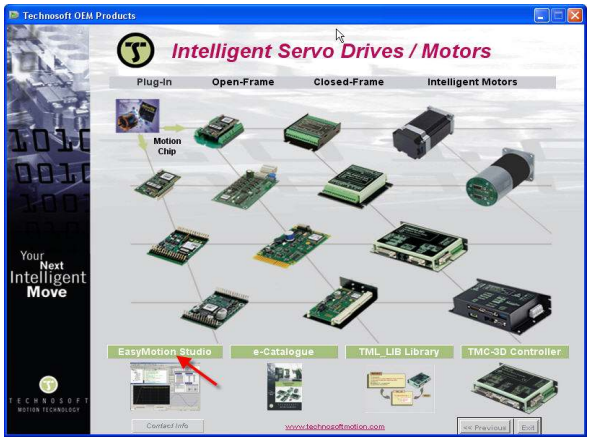
What You will Need:

- Host computer: An IBM PC, AT or compatible, with hard disk, CD-ROMM drive, NGA or SVGA monitor, running under Windows (version 95, or 98, Millennium, or NT4.0, or 2000, or XP). Windows ME is not supported
- Power requirements: 12 – 48 VDC with up to 3A(rms) load current for motor.
- Controller: LAC20 with appropriable cable
- Motor: SMAC linear actuator or linear/rotary actuator.
- Port: Asynchronous RS-232 serial communication link
- Serial cable: SMAC communication kit

Installing the EasyMotion Studio Software

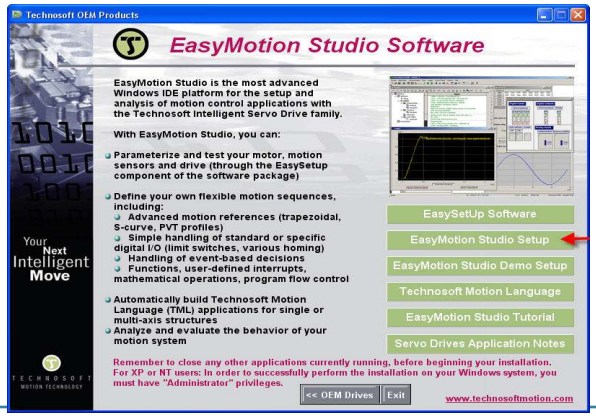
- Insert the setup CD-ROM into the CD-ROM drive unit and setup program will automatic starting. If the automatic starting failed, go CD-ROM drive folder and start **Setup.exe** file.

- Select the "EasyMotion Studio" menu item



- After entering "EasyMotion Studio Software" page, press the "EasyMotion Studio Setup".

- Following the instructions and answer the questions during the installation procedure.



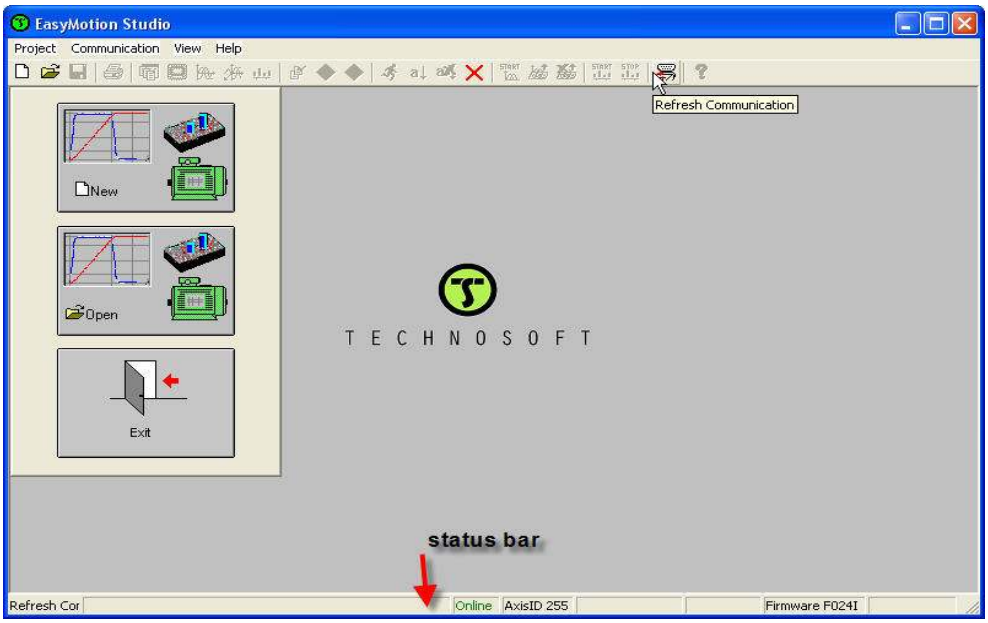
Verifying the Installation:

● Connecting the communication cable to PC and LAC20

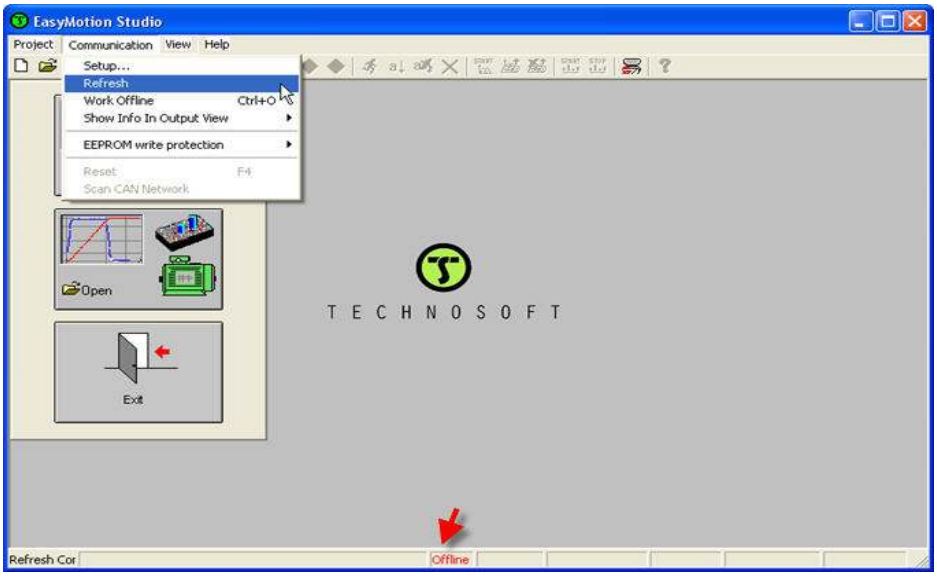
● Powering up the drive

● Starting EasyMotion Studio by using the Windows "**Start | Programs | EasyMotion Studio | EasyMotion Studio**" menu command

● If the communication works properly you will see displayed on the status bar (the bottom line) of the EasMotion Studio, "Online", the axis ID of the drive, and the firmware version.



● If the LAC20 is not detected, the "offline" message is displayed on the status bar. First, checking the serial cable and, power supply connections to the LAC20. Also checking the serial port set, it may be used by other devices. After the problems being fixed, use menu command "**Communication | Refresh"** to restore the connection.

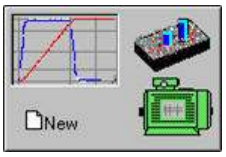


On-line Help

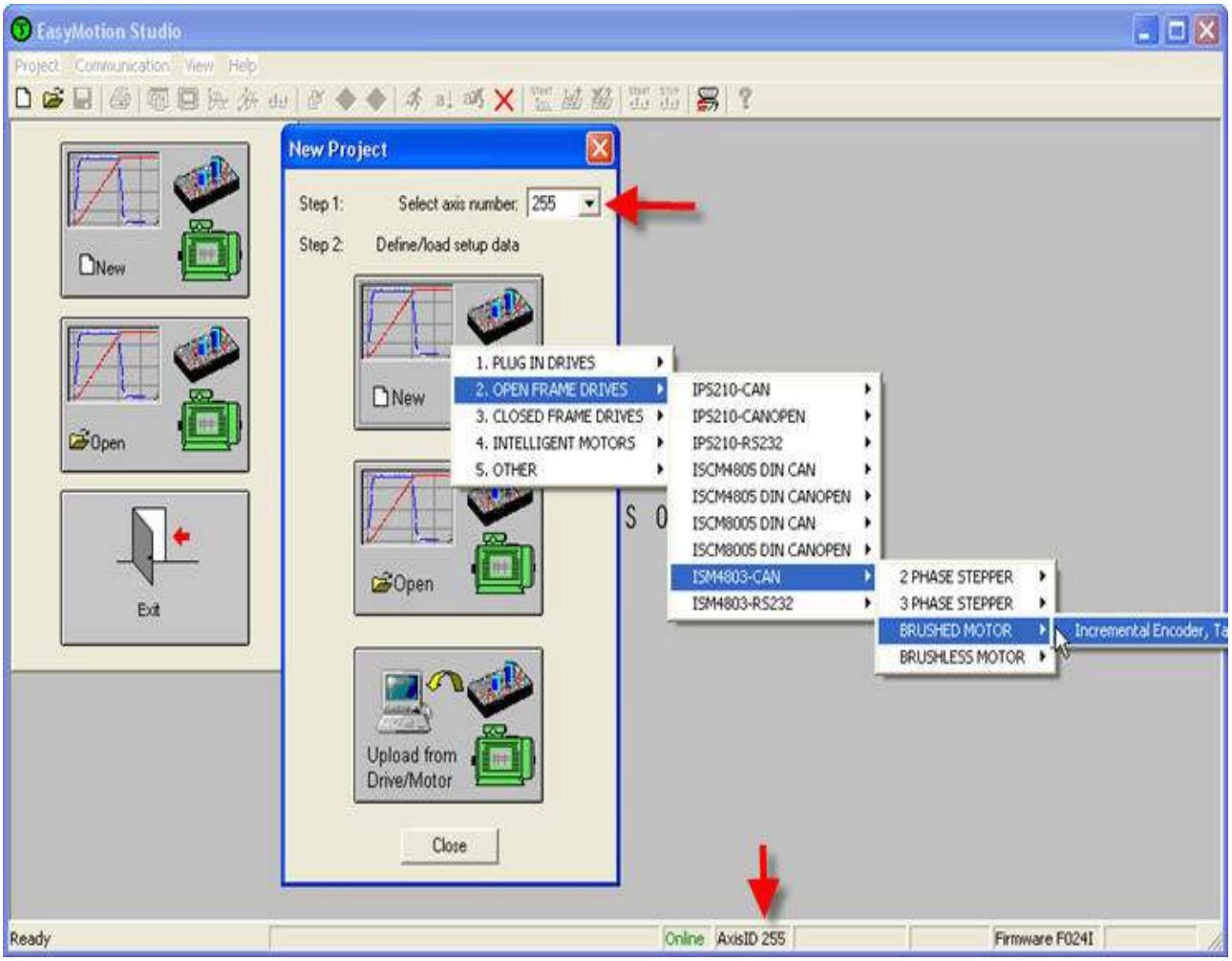
Now, the communication connection between LAC-20 controller and your PC has been established. For the first time using **EasyMotion Studio**, it is recommended that you first read the "**Getting Started**" that included in the on-line help. With menu command "**Help | Getting Started**", you will see the different tutorial lessons that are also available.

Project Set-up:

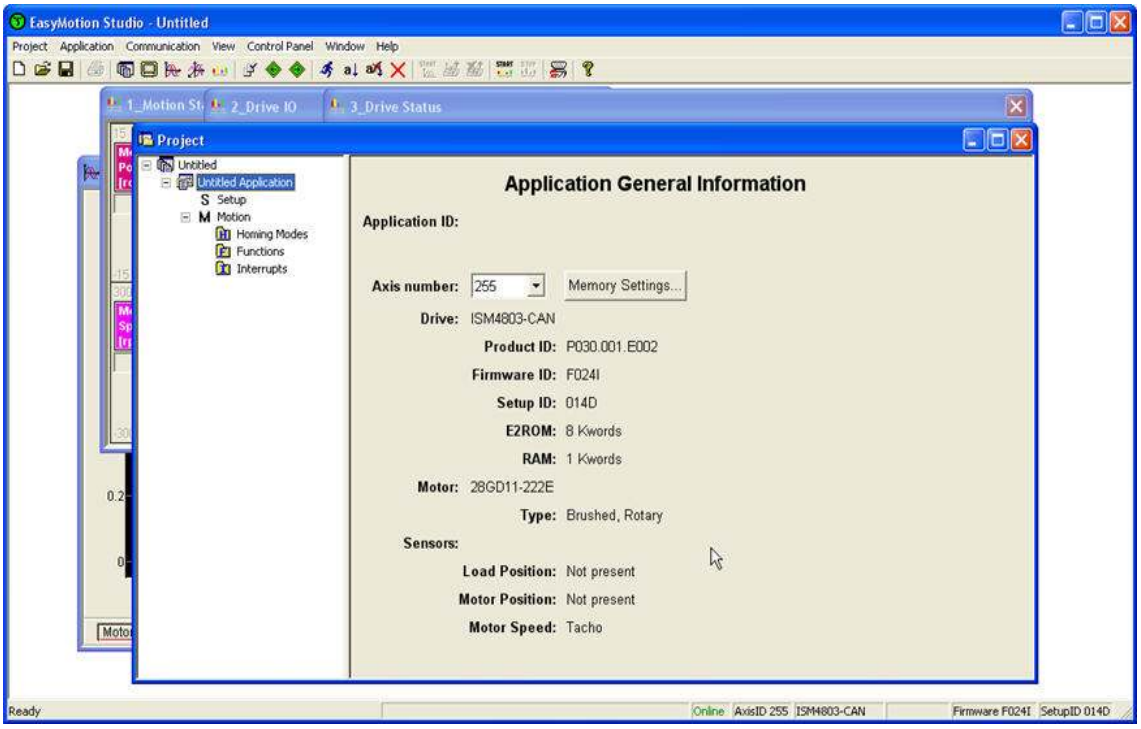
After launching EasyMotion Studio, an empty window is created in where you can create a new project or open a previous created project.

Press New button 

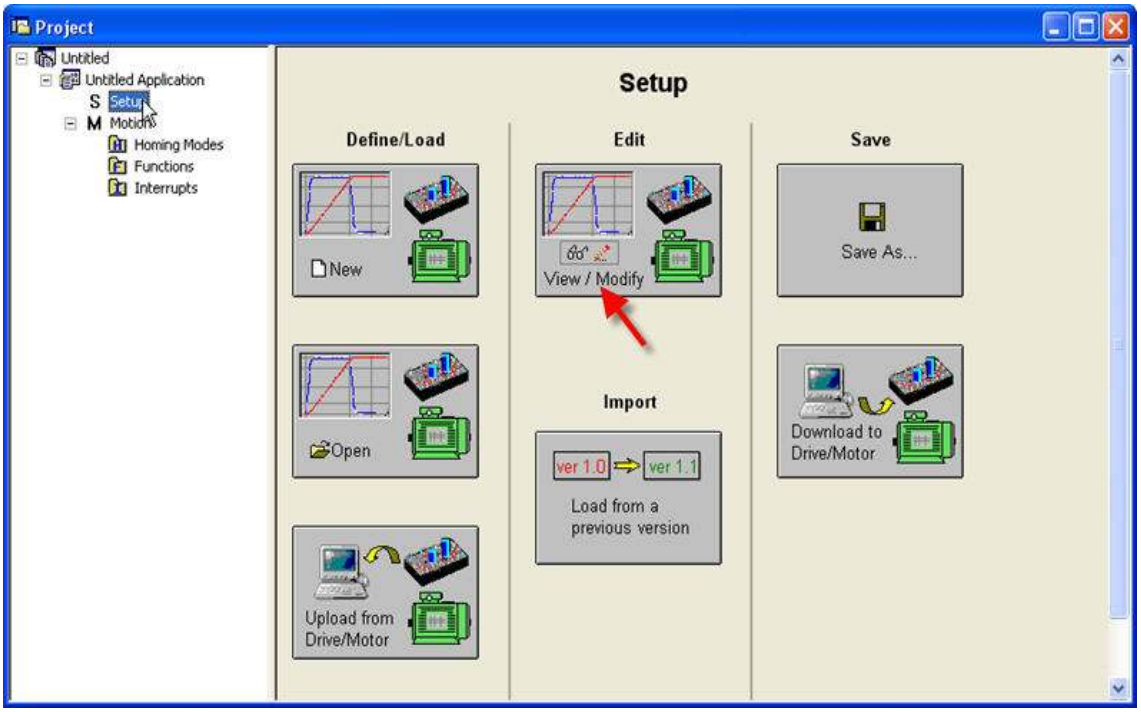
to open a "New Project" dialogue. Set the axis number for your application equal to the drive axis ID. The initial default number is 255, the default axis ID of the drive. Press **New** button and select the drive type of **ISM4803-CAN**, the motor technology of **BRUSH MOTOR** and feedback device of **Incremental Encoder**.

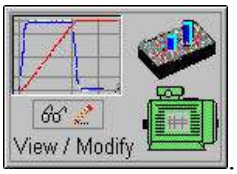


EasyMotion Studio opens a **Project** window as following: left side shows the project structure and right side is application information. At beginning both the new project and its first application are named “Untitled”. The application has two components: **S** Setup and **M** Motion (program)



In the left side of project window, select “S Setup” to bring up the Setup application.



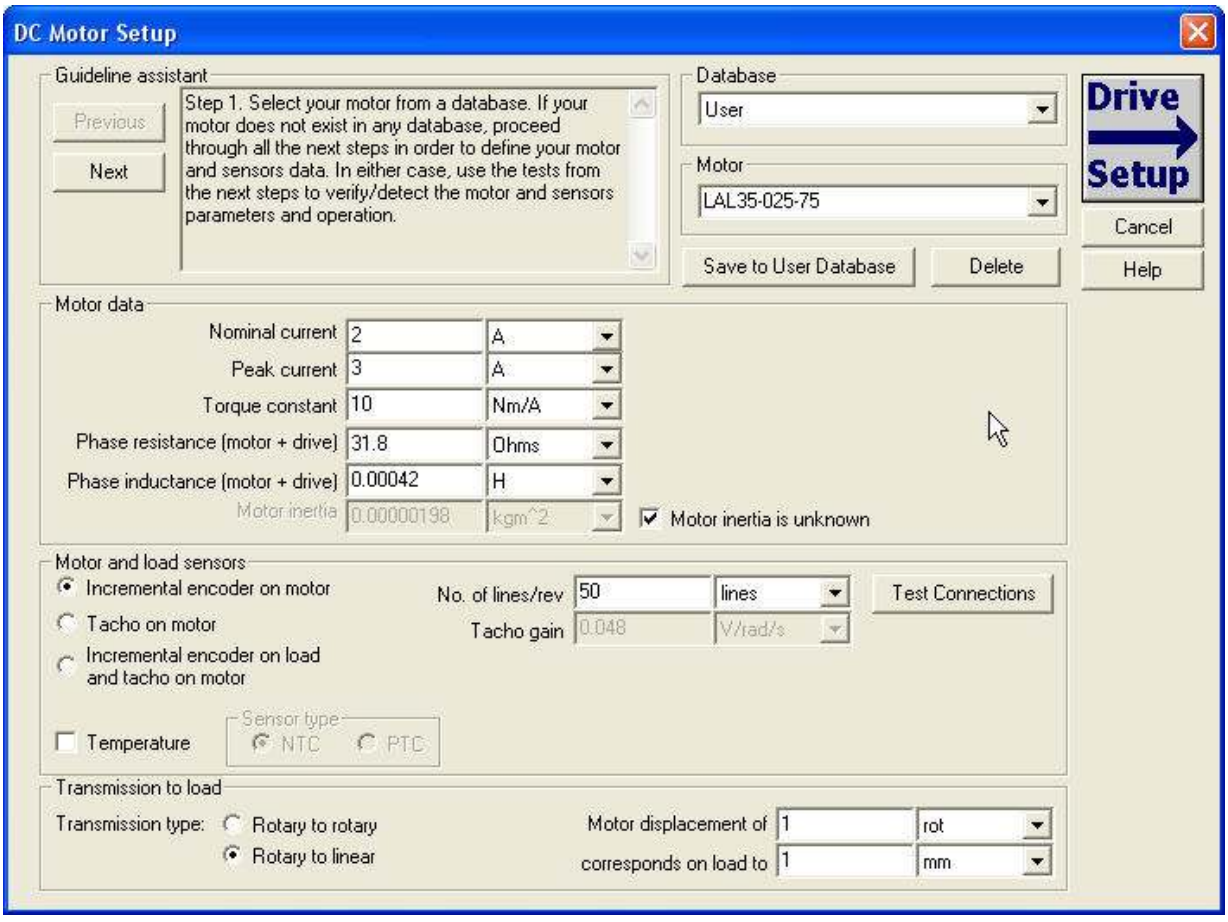
Press View/Modify button, 

. It opens two setup windows, **Motor Setup** and **Drive Setup**. Through these two dialogue setup, you can configure the motor data and set the parameter values in the drive for your application. A series tests help to check the connections to the drive and/or to determine the motor and sensors parameters. In each setup dialogue, a guideline assistant will guide you through the whole process of checking data.

Motor Setup

In the Motor Setup windows, motor specification data entry here. The key data is the set of motor wire resistance, inductance, and torque consistence. The motor Normal current and Peak current are also two critical data.

Check carefully the motor Normal current and Peak current values. During the motor tests, the power is applied to motor and test current is based on the motor nominal current and the set of over current protection function of peak current. If those two values are incorrectly entry, the test can damage motor!

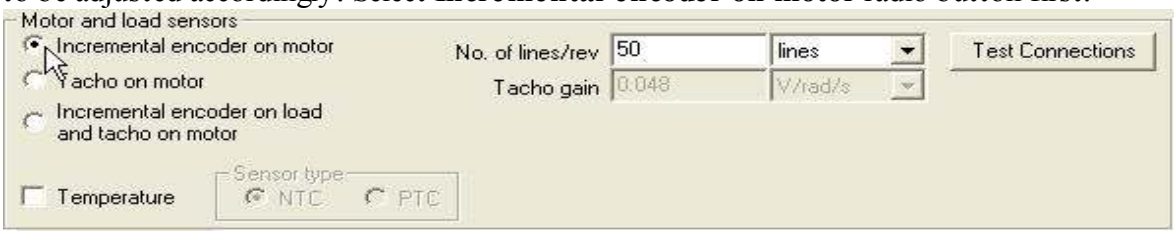


There are two methods to configure the motor, choose one from existing data base; or modify one motor to create new one.

In the first case, choosing one from **Database**, User, then go through **Motor** list. Select one motor, for example LAL35-025-75. The LAL35 actuator has 25mm stroke, 48V single coil and 5um encoder. If the actuator that to be run is slight different, for example it has hot coil, you need to adjust the data accordingly. In the second case, start from an actuator in the database and modify the data to be the new actuator. When you make some changes in the existent actuator, the actuator name gets the suffix (**Modified**). It indicates that you can save the actuator data in the database **User** with the proper name. Press the **Save to User Database** button for the operation.
In the User database, you may also **Delete** motors/actuators when you don't need it.

Encoder data entry:

Since the same type of actuators may have different resolution of encoder, the data entry here needs to be adjusted accordingly. Select **Incremental encoder on motor** radio button first.

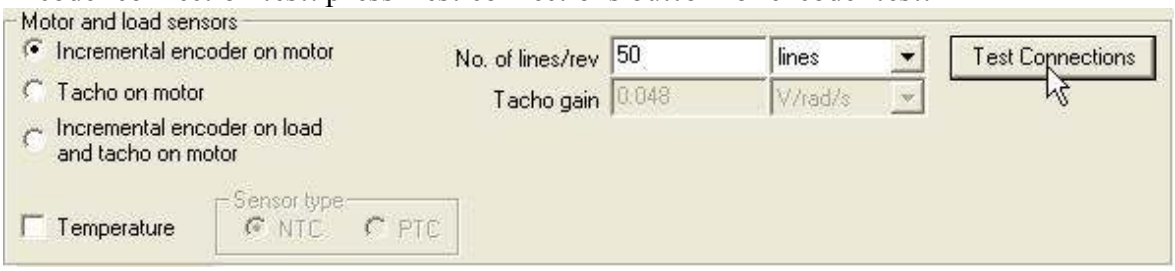


The number of line per revolution is determined according to encoder resolution, number encoder count per mm divided by 4.

Encoder resolution (um)	Encoder count / mm	Lines / mm
5	200	**50**
1	1,000	**250**
0.5	2,000	**500**
0.1	10,000	**2,500**
0.05	20,000	**5,000**

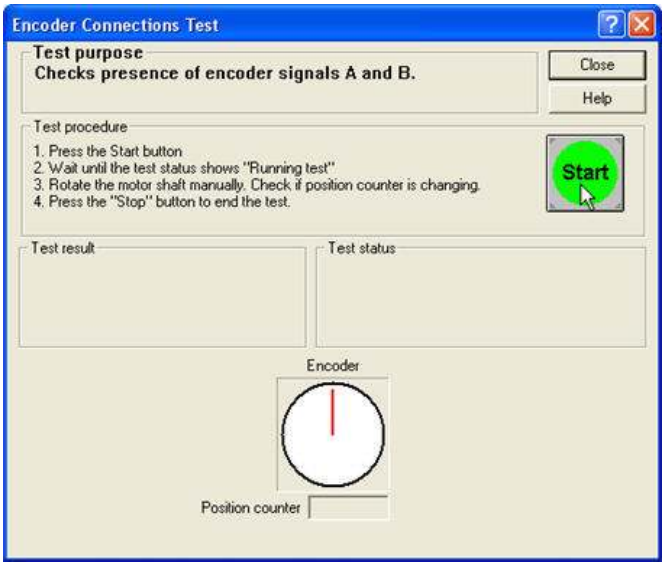
Select Transmission type: Rotary to linear. Enter 1 in both The Motor displacement and correspond on load.

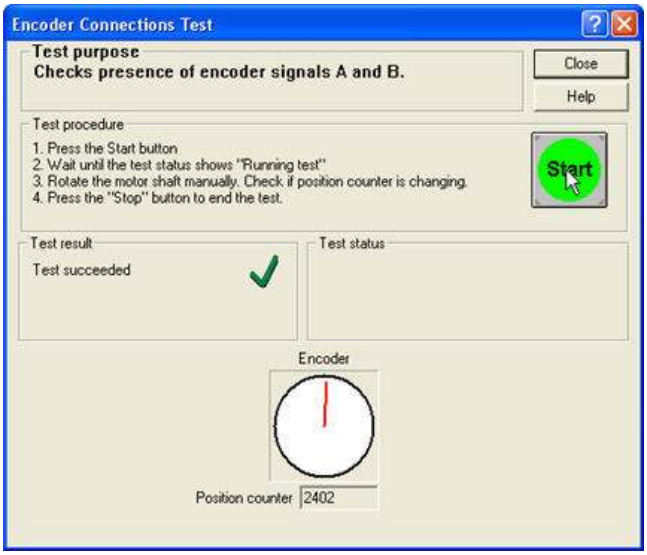
Encoder connection test: press Test connections button for encoder test.



The encoder test is for testing the presents of encoder signal A and B.

Press the start button for testing, then start move actuator rod/shaft and testing result will be displayed in the Position counter as number of encoder counts during the test.





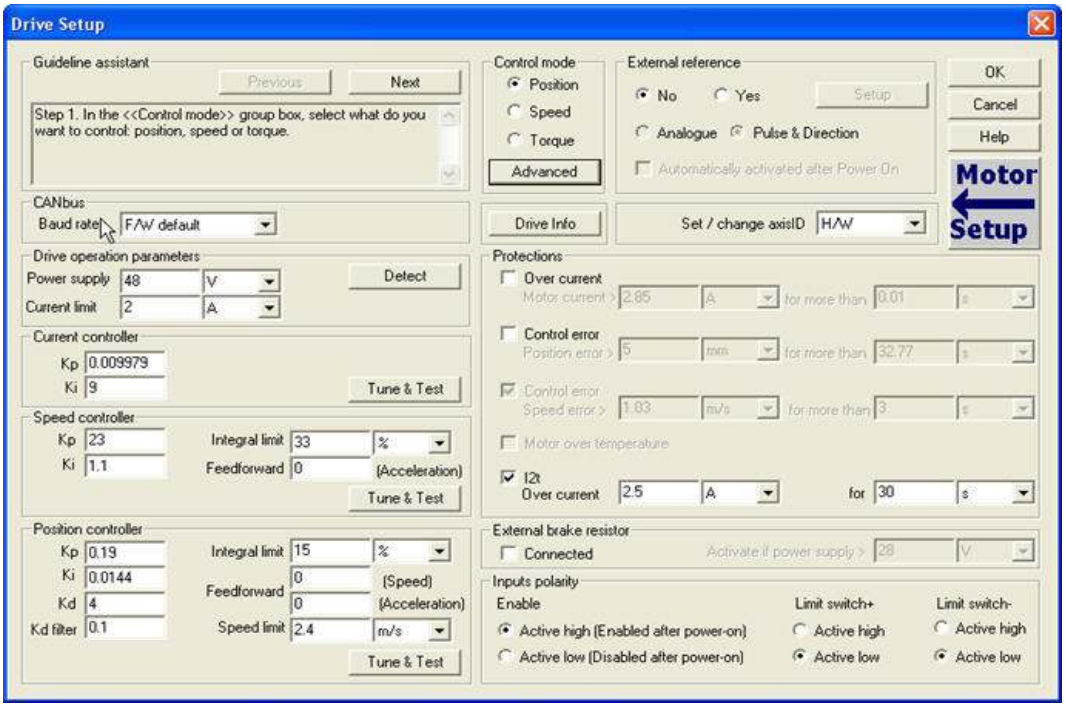
During the testing, you can monitor the Position counter. When you extend the shaft, the encoder count should be increasing positively and retract the shaft, encoder count should be decreasing negatively. Also, notice that try to make Encode diameter run one cycle, the Position counter should show around 200 for 5um encoder. Press **Stop** button to stop the testing and testing result will be show the message "Test succeeded" with a **Green Check** mark.

Drive Setup

Go to the Drive Setup window you can configure and set parameter values to the drive for your application. Go to this window **only** after you already finished the motor data and encoder data setup in Motor Setup window.

The Guideline Assistant can help you to following the steps described. This will guide you through the whole process during the setting up the drive. The **Next** button shows the next guideline step. The **Previous** button is for back to the previous step.

The Drive Setup also provides a series tests to the drive parameters and overall system behavior according to your application. The drive power supply and drive current limit are critical data. If those data is not correct, the test will not work correct or can damage your motor.

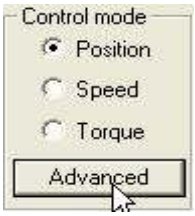


● Select the drive **Control Mode**, three modes:

Position - position control

Speed - speed control

Torque - torque / current control



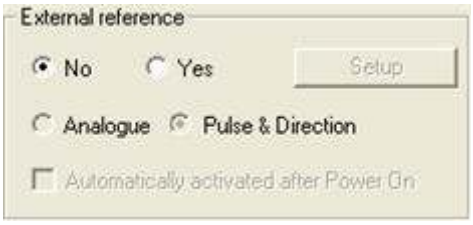
If the application needs to switch between position and speed control, select **Position**, then press the **Advanced** button and in the group **Control scheme** choose the option **Close position, speed and control loop**.

The default option for position control is to **Close only position and current loop**. In this configuration, the position controller output is a current/torque command. The speed controller is not used.

● Select the motion reference type in the **External reference** group box:

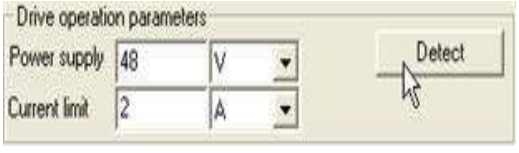
Yes – drive gets the reference from an external device

No – drive gets the internal reference generator. For most of case, choose No since most SMAC actuators are not equipped with an external device.



● Set the Drive operation parameters:

Power supply: for the power on the motor supply. Press **Detect** button to measure the actual voltage applied to the motor drive. The supply voltage is used in current control turning.



Current limit: The maximum current drive can used to control the motor. The current limit must be set to bigger than the motor nominal current for dynamic motion. It can not be set to bigger than motor peak current.

● **Current Control Set and Tuning**

Kp – Proportional gain for current controller

Ki – Integral term for current controller

Press the **Turn & Test** button on current controller to open the window for **Current controller tuning,** in where you can test and tune the motor response to the current controller.

There are two steps:

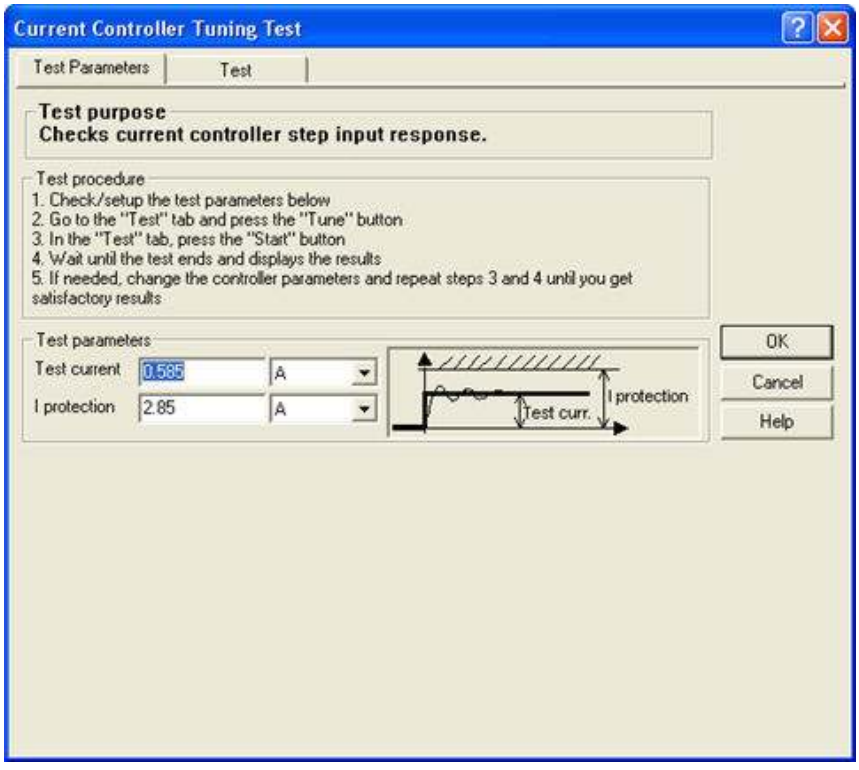
a) Set test parameters in the "**Test parameters**" tab

b) Run the test in "**Test**" tab

"This is a 'hot' test. It applies power to the motor. It sets a current reference and during run time it captures and displays the motor current, current reference and voltage reference values. The test does not move the motor."

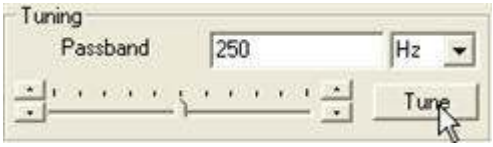
Test Parameters tab:

When enter the dialogue, the "Test current" is set to be suggested half of motor nominal current. You may increase the test current value up to 90% of the motor nominal current or drive nominal current which is the smaller.

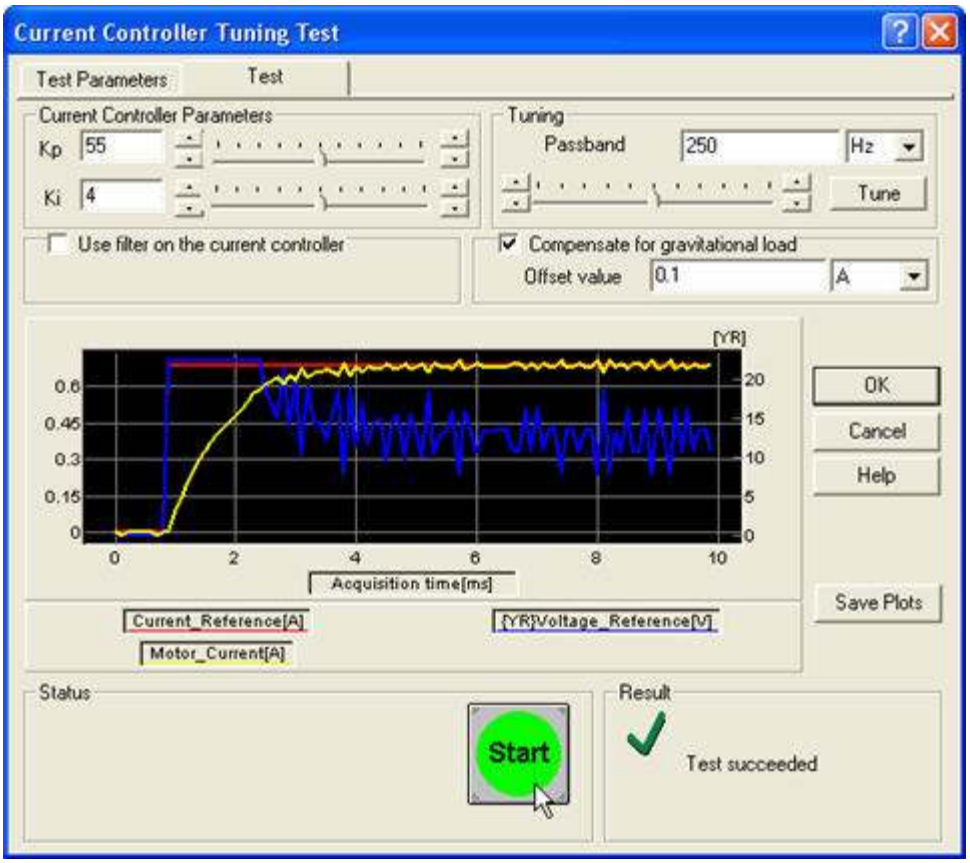


The "I protection" sets the over current protection limit. The maximum value of "I protection" is limited to motor peak current or drive peak current if it is smaller. "I protection" value must be bigger than the "Test current"

Test tab:



- Check and enter parameters, Kp and Ki
- In the "Tuning" group box, press "**Tune**" button to have automatic tuning. I t sets the parameter values according to the passband chosen, motor data and power supply voltage value.
- Check "Use filter on the current controller" if you want to apply a filter to the current reference.
- Check "Compensate for gravitational load" and set the "Offset value". For the reason of gravitation, you can add an offset value to current reference to compensate the gravitational force.
- Press "Start" button and wait unit the result is displayed. Adjust the parameter values if it is needed and repeat the test by pressing the "Start" button again.



Validation of Test Result:

You need to visually inspect the result showed in the graph. If the controlled current reaches the reference current with acceptable performances such as response time, overshoot, errors, you determine the results. Otherwise, change the parameter values and perform the test again.

Press **OK** button to save the actual parameter values. Otherwise, press **Cancel** button to leave unchanged parameters. Both actions will return to the Drive Setup window.

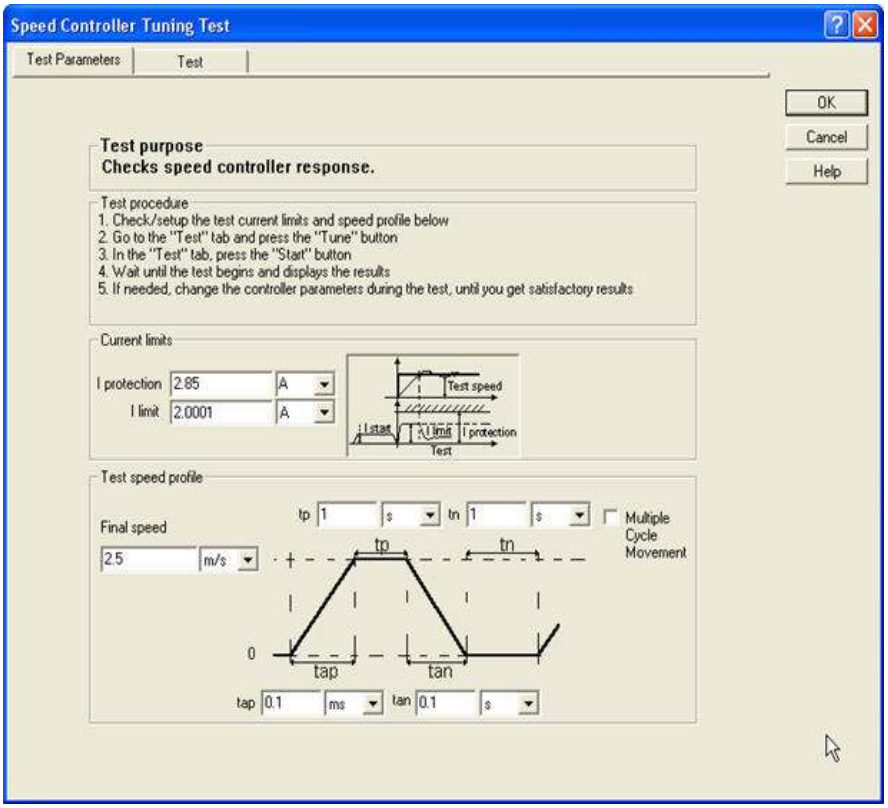
● **Speed Control Setup and Tuning**

Kp – proportional gain term for speed controller
Ki – integral term for speed controller
Integral limit – saturation limit for the integral term of speed controller
Feedforward – acceleration feed forward (only in speed control mode)

Press "**Tune & Test**" button to open the window of Speed controller tuning, in where you can tune the motor with speed controller and test its behavior. There are two steps:
Set up the parameter values in "**Test parameters**" tab
Run the test in "**Test**" tab

"This is a 'hot' test. It applies power to the motor. It sets a speed reference and during run time it captures and displays the load speed, speed reference, motor current and current reference values."

Test Parameters tab



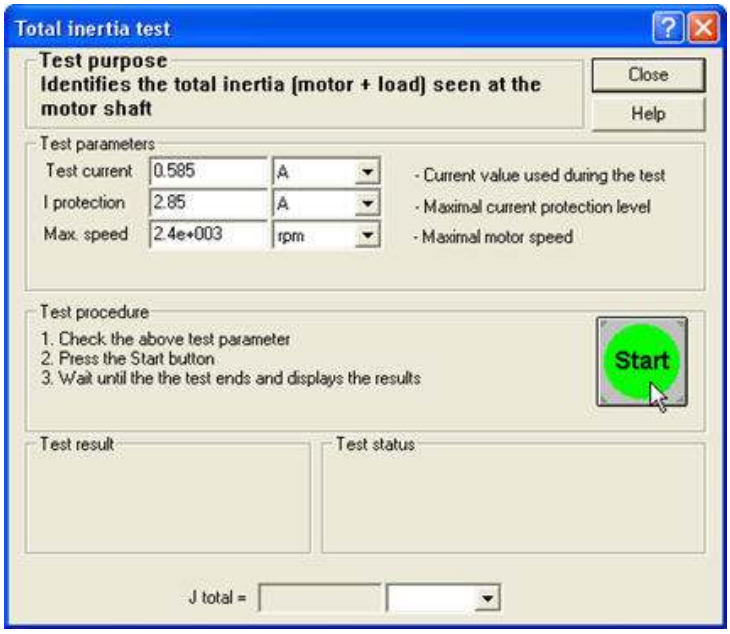
The "**I Protection**" sets the over current protection limit. The protection time is set to minimum. The "I Protection" parameter must be bigger than the "I limit: value.

The "**I limit**" sets the drive output current limit.

The test let you to define a speed profile from the "**Test speed profile**" box. When you enter the values, the program will suggest the "final speed". You may change this value to limit the motor maximum accepted speed.

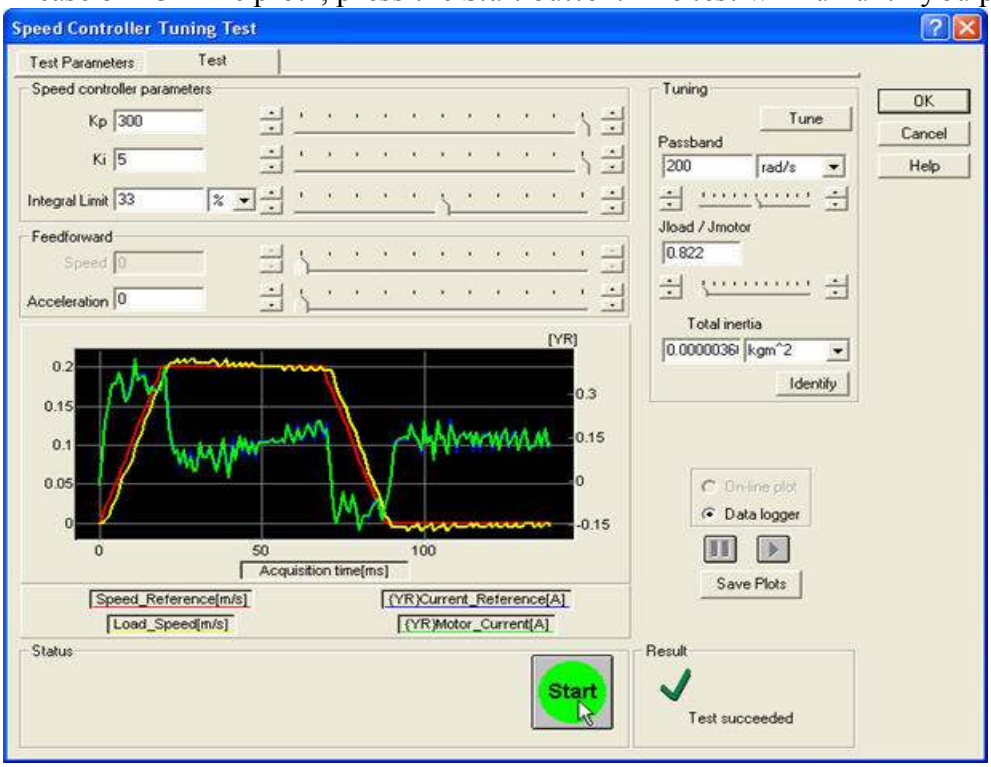
Test tab:

- Check the parameters for the speed controller
- In the "Tuning" box, verify the ratio (load inertia / motor inertia) or the total inertia. If you could not determine, press "Identify" button to estimate the total inertia through Total Inertia Test.
  "The total Inertia Test is a "hot" test. It applies power to the motor. **The test must be done only after performing the current controller tuning.** The test injects a current in the motor and measures its acceleration. Based on these data, and the motor torque constant, the total inertia is calculated as seen at motor shaft."



- Press the "Tune" button to set the controller parameters according with the pass-band chosen, motor data and the total inertia value.
- Two methods to see the test results:
  On-line plot
  Data logger

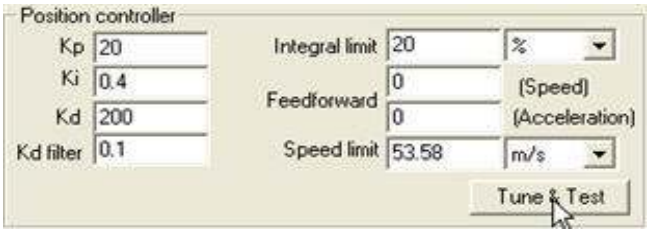
In case of "On-line plot", press the Start button. The test will run until you press the Stop button.



Validation of Test Result:
You need to visually inspect the result showed in the graph. If the load speed follows the speed reference with acceptable performances such as response time, overshoot, errors, you determine the results. Otherwise, change the parameter values and perform the test again.

Press **OK** button to save the actual parameter values. Otherwise, press **Cancel** button to leave unchanged parameters. Both actions will return to the Drive Setup window.

● **Position Control Setup and Tuning**

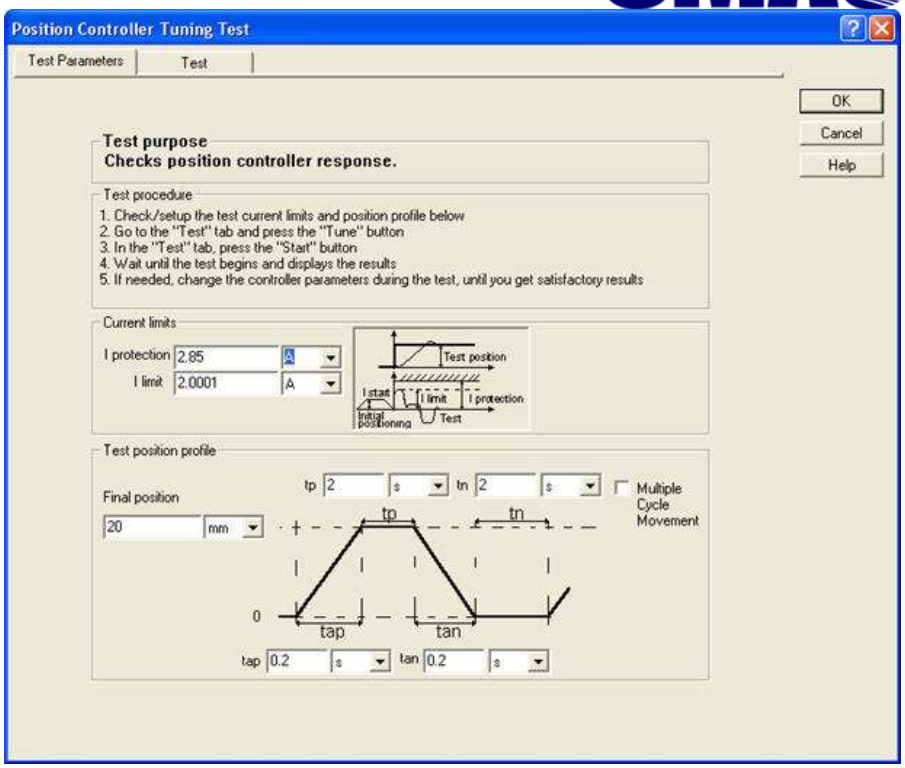


Kp – proportional gain term of the PID for position controller
Ki – integral term of the PID for position controller
Kd – derivative term of the PID for position controller
Kd filter – filtering coefficient for the derivative term of the PID for position controller
Integral limit – saturation limit for the integral term of the PID for position controller
Feedforward – acceleration and speed feed forward (speed feed forward is only available when the speed loop is closed)
Speed limit – maximum speed command set by the position controller (only when the speed loop is closed)

Press "**Tune & Test**" button to open the window of Position controller tuning, in where you can tune the motor with position controller and test its behavior. There are two steps:
Set up the parameter values in "**Test parameters**" tab
Run the test in "**Test**" tab

"This is a 'hot' test. It applies power to the motor. It sets a position reference and during run time it captures and displays the load position, position reference, and also
The motor current and current reference values, if speed loop is not closed, or
The load speed and the speed reference, if speed loop is closed.

Test Parameters tab



The "**I Protection**" sets the over current protection limit. The protection time is set to minimum. The "I Protection" parameter must be bigger than the "I limit: value.

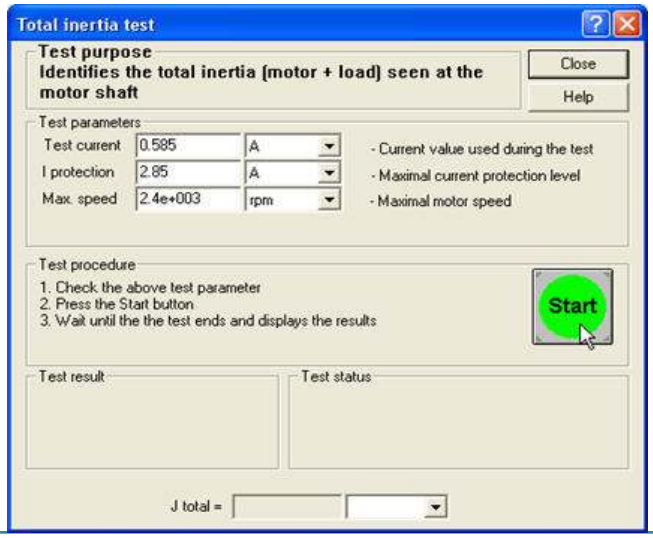
The "**I limit**" sets the drive output current limit. The maximum current command allowed in the test.

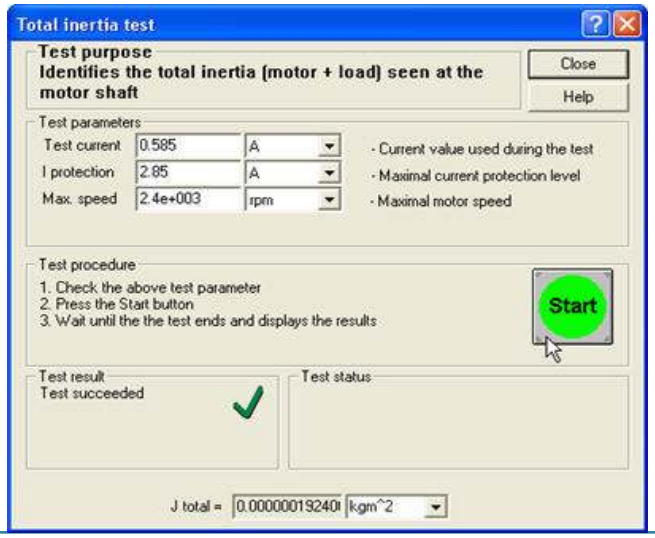
The test let you to define a position profile from the "**Test position profile**" box. When you enter the values, the program will suggest the "final position". You may change this value to limit the motor maximum accepted position.

Setting the time intervals of "tap", "tan" as well as "tp" and "tn", you can generate step, ramp, or trapezoidal position profile. Check or uncheck the box "**Multiple Cycle Movement**" for single or repetitive cycle.

Test tab:

- Check the parameters for the position controller
- In the "Tuning" box, verify the ratio (load inertia / motor inertia) or the total inertia. If you could not determine, press "Identify" button to estimate the total inertia through Total Inertia Test.





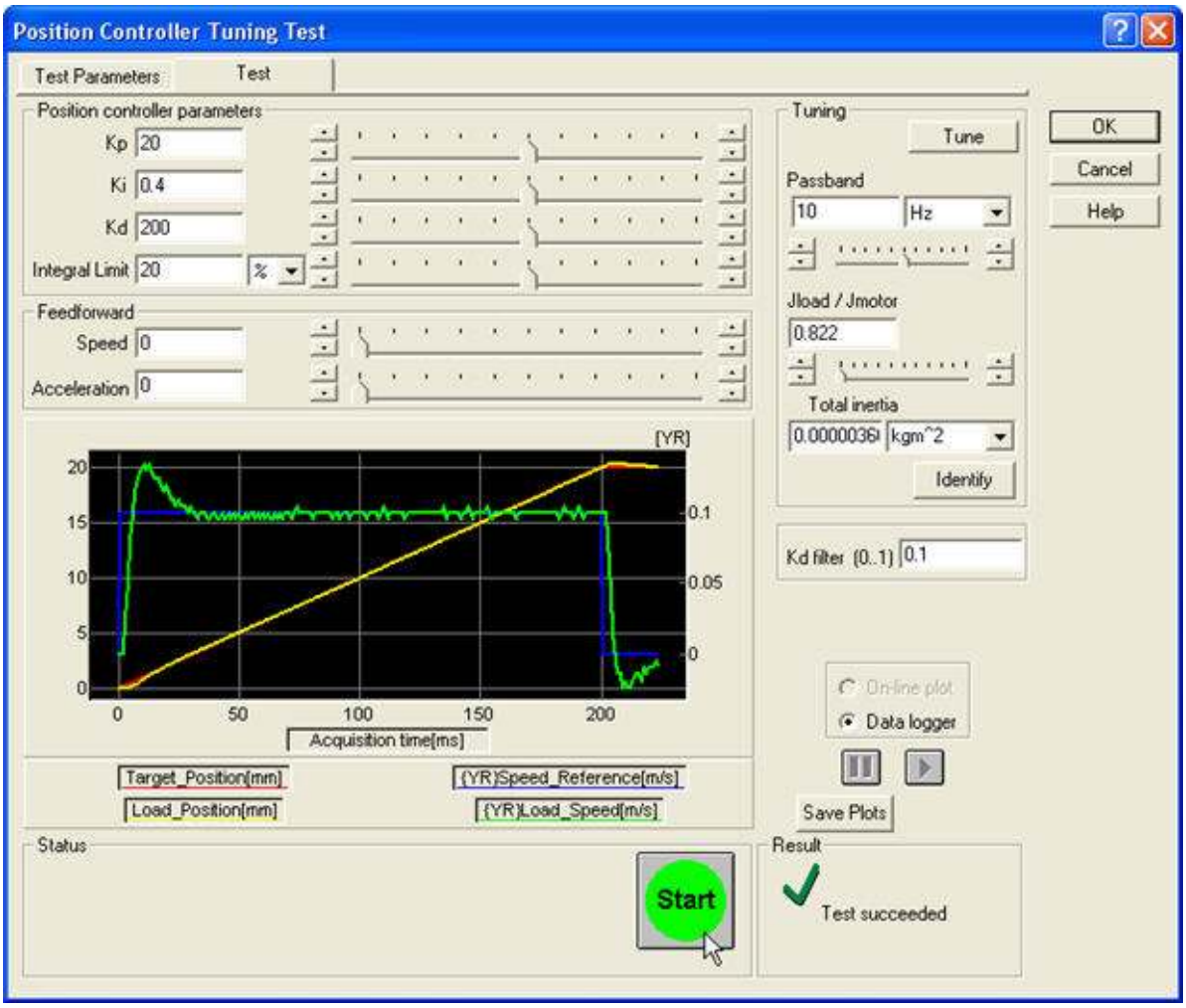
The total Inertia Test is a "hot" test. It applies power to the motor. **The test must be done only after performing the current controller tuning.** The test injects a current in the motor and measures its acceleration. Based on these data, and the motor torque constant, the total inertia is calculated as seen at motor shaft."

- Press the "**Tune**" button to set the controller parameters according with the pass-band chosen, motor data and the total inertia value.
- Two methods to see the test results:

On-line plot

Data logger

In case of "On-line plot", press the **Start** button. The test will run until you press the Stop button.



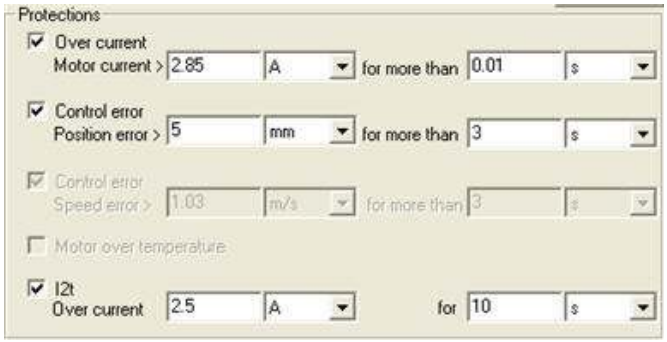
If the adjustments are need to parameters values, you can repeat the test by pressing the Start button again until the test results are satisfied.

Validation of Test Result:
You need to visually inspect the result showed in the graph. If the motor position follows the position reference with acceptable performances such as response time, overshoot, errors, you determine the results. Otherwise, change the parameter values and perform the test again.

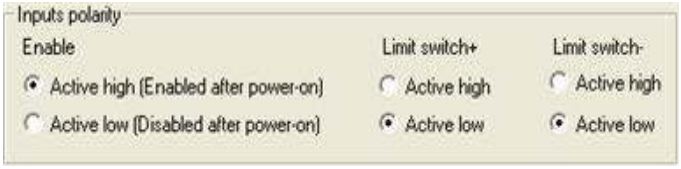
Press **OK** button to save the actual parameter values. Otherwise, press **Cancel** button to leave unchanged parameters. Both actions will return to the **Drive Setup** window.

In the Drive Setup window, there are some other group boxes as following:

● **Protections**
Select proper values in each box to making protection during the test.



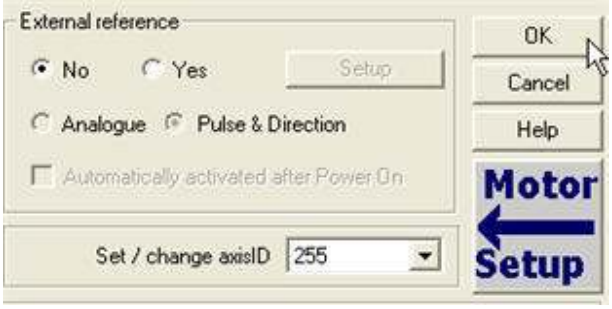
● **Inputs polarity**
The dedicated inputs, Enable and limit switch need to be specifying input active level.
Enable – when this input is in active, the drive is enabled. To execute the setup tests, the active level must set on: enabled after power on.



Limit switches(+/-) - when one of those two inputs is activated, the drive will be in stop mode. In order to execute the setup tests, these inputs must be set to inactive level.

● Set / change axis ID
Selecting the Axis ID for the drive. Choose H/W (hardware), drive will read the axis ID from hardware switch setting.
Choose any other value to impose an Axis ID regardless other setting. The selected ID will be effective after downloading the setup data and resetting the drive. The default axis ID is 255.

Press **OK** button to keep all the changes on the motor and drive setup. Press **Cancel** button to exit without save all the changes during the setup procedures. Press the **Motor Setup** button to return to Motor Setup window.



● **Download the Setup data to the drive**

In the **Setup** part of **Project** window, Press the **Download to Drive/Motor** button to download the setup data into the drive/motor EEPROM memory, in the setup table. After download, every time power on, the setup data is copied into the drive/motor RAM memory and is used during run time. It also can save the setup data in PC and be used in other applications. Also, the complete setup data in the drive/motor can be uploaded.

Summary for the Motor and Drive Setup:

You can define or change the setup data of an application in the following methods:

- Create a new setup data by going through the motor and drive dialogues
- Use previously saved setup data in PC
- Use previous saved setup data and modify data according to the application and saved into new application setup data
- Upload setup data from a drive/motor EEPROM memory

Program Motion

The Technosoft Motion Language (TML) Overview

The Technosoft Motion Language is a high level language that allows you to:
● Setup a drive built with Motion Chip a given application
● Program and execute motion sequences

The setup part consists in assigning the right values for the TML registers and parameters.

Program part is for motion programming. TML let you to:
● Set various motion modes (profile, electronic gearing, camming, etc.)
● Change the motion modes and/or the motion parameters on-the-fly
● Execute homing sequences
● Control the program flow through
- Conditional jumps and calls of functions
- Interrupt generated on pre-defined or programmable conditions
- Wait for programmed events to occur
● Handle digital I/O and analog inputs
● Arithmetic and logic operations
● Perform data transfers between axes
● Control motion of an axis from another one via motion commands sent between axes
● Send commands to a group of axes (multi cast)

TML Program Structure

The main section of a TML program starts with the instructions BEGIN and ends with the instruction END.

```
BEGIN
……
END
```

It has two parts:
● Setup part
● Motion programming part

Setup Part:

```
BEGIN
….
ENDINIT
```

The setup part mainly consists of declaration and assignment instructions, which sets the TML registers and parameters in accordance with the application data. After ENDINIT command is executed, the basic configuration involving the motor and sensors types or the sampling rate, can not be changed unless a reset is performed.

The motion programming part starts after the ENDINIT instruction until the END instruction. All the TML programs (the main section) should end with the instruction END. When END instruction is executed, the sequential execution of a program is stopped.

In the main program section, it may also include the interrupt vectors table, the interrupt service routines, and functions.
A typical structure of a motion program:

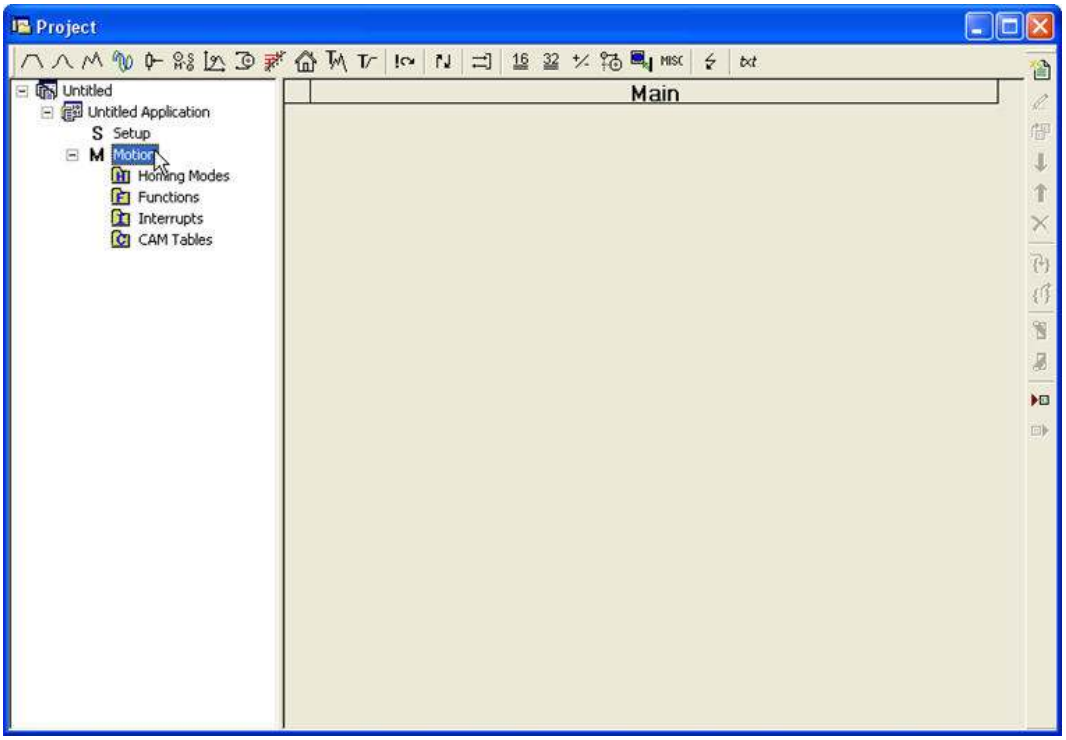
```
BEGIN;                                  // Program Start
…..
                                        // Setup part of the main section
…..
ENDINIT;                                // End of initialization
…..
                                        // Motion programming part
…..
END;                                    // end of the main section

Interrupt Table:                        // start of the interrupt vectors table
@int0_Axis_disable_ISR;
@int1_Short_circuit_ISR;
@int2_Software_protection_ISR;
@int3_Control_error_ISR;
@int4_Communication_error_IS
R;
@int5_Wrap_around_ISR;
@int6_Limit_switch_Pos_ISR;
@int7_Limit_switch_Neg_ISR;
@int8_Capture_ISR;
@int9_Motion_complete_ISR;
@int10_Time_period_ISR;
@int11_event_reach_ISR;
Int0_Axis_disable_ISR:                  // body of Int0
…..
RETI;                                   // return from ISR
…..
Int11_Event_reach_ISR:                  // body of Int11
…..
RETI;                                   // return from ISR
Function1:                              // Start function1
…..
RET;                                    // return from function1
…..
FunctionX:                              // start functionX
…..
RET                                     // return from functionX
```

EasyMotion Studio includes a Motion Wizard.

The **Motion Wizard** provides the possibility to program all the motion sequences using high level graphical dialoguers which automatically generate the corresponding command instructions. With this **Motion Wizard**, you can develop a motion program using almost all the TML instructions without needing to learn them.

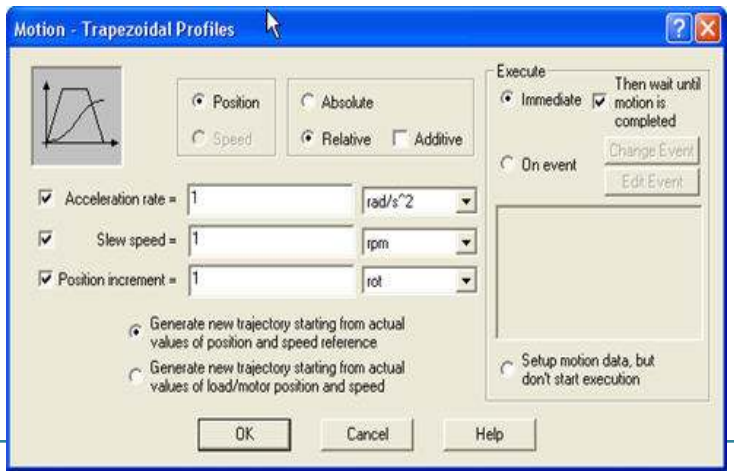
In the project window left side, select "**M** Motion" and the Motion Wizard is automatically activated.



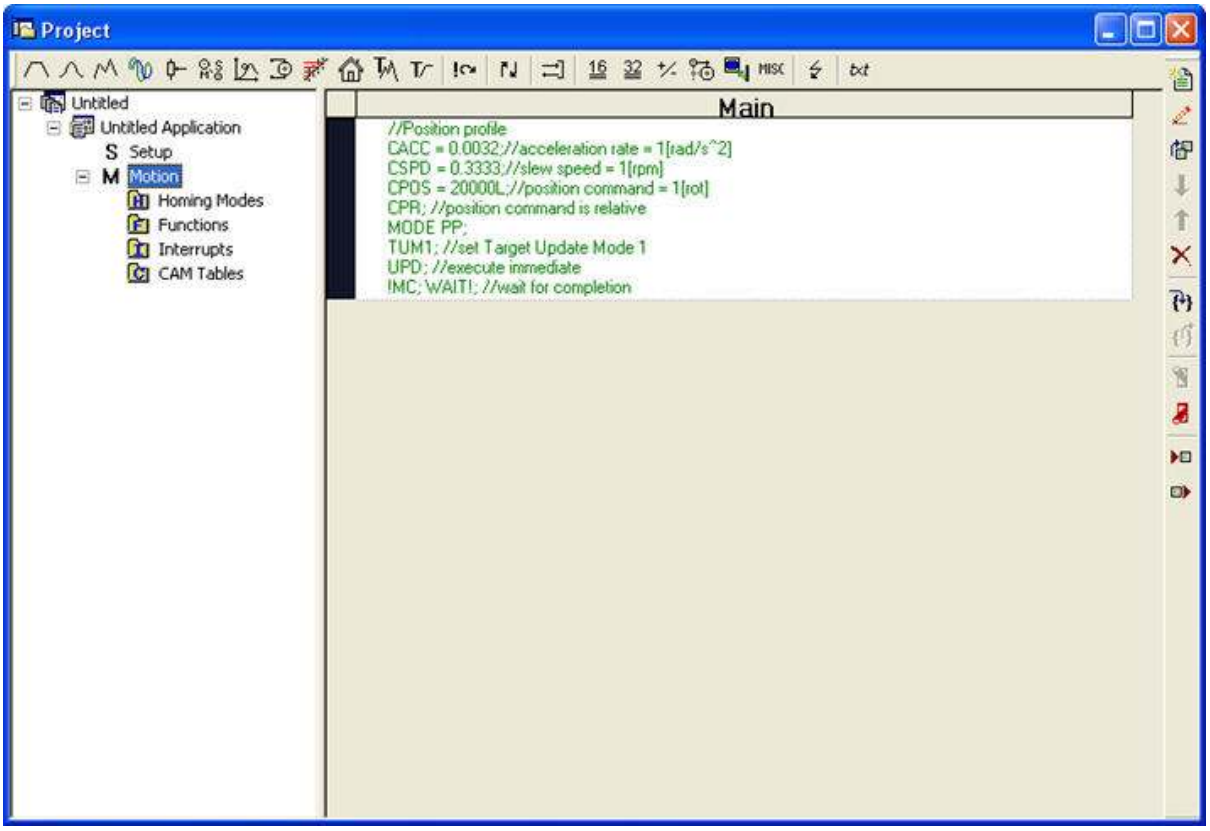
When activated, **Motion Wizard** adds a set of toolbar buttons in the project window. Each button opens a programming dialogue. When a program dialogue is closed, the corresponding instructions are automatically generated. The command instructions generated are not a simple text, but a motion object. Therefore, the **Motion Wizard** provides you motion program as a set of motion objects.

For example, first push a left most **Motion Wizard** button,

Motion – Trapezoidal profiles. The program dialogue is open and it allows you to program a position or speed profile with a trapezoidal shape of the speed.



Press **OK** button after set the position and speed, a program is generated in the main section.



Then, press the  "run" button.

At this point the following operations are done automatically:

- A TML program is created by inserting your motion object into a predefined template
- The TML program is compiled and downloaded to the drive
- The TML program execution is started

EasyMotion Studio also includes a set of evaluation tools like the Data Logger, the Control Panel and the Command Interpreter which help you to quickly measure and analyze your motion application. Please go to EasyMotin Studio on-line help for details about those evaluation tools.

Sample Motion Program: